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Vankov, P.H.

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Summary

The Large Hadron Collider (LHC), scheduled to start operations this year at CERN, will accelerate and collide proton beams at 14 TeV center-of-mass energy at luminosities up to 10^{34} cm^{-2}s^{-1}. In these collisions the heavy B mesons (bound states of a b quark and a light antiquark) will be produced at high rate, thus allowing precise measurements of the violation of the combined Charge-Parity (CP) symmetry in the B system and the study of rare B decays. A dedicated experiment, LHC*b*, will operate with LHC to exploit this possibility.

The research in this dissertation addresses two issues: the overall performance of the LHC*b* Outer Tracker (OT) detectors as shown during quality checks and beam tests; the study of the lifetimes of B^+ and B^0 mesons at LHC*b*.

The OT system of LHC*b* comprises three stations consisting of layers of straw tubes in vertical and non-vertical (± 5 deg) orientation. The basic element of the OT stations is the module, a self-contained gas-detector unit, built of arrays of straw-tube drift cells and filled with a mixture of Ar (70%) and CO_2 (30%).
The quality of the OT modules was strictly checked during their construction (Chapter 3). To make sure that no deviations from the design specifications [52] were present, a variety of quality assurance tests were carried out: inspection of the anode wire quality, control of the friction force of the wire locators with the straw, control of the position of the wire inside the straw, systematic measurement of the wire tension, systematic measurement of the current of each wire in air at high voltage (HV), systematic measurement of the gas tightness of each OT module, HV training of the channels of the module in a counting gas and final validation of the module with a radioactive source with counting gas. The results of these tests, presented in this dissertation, showed that the performance of the OT detector fulfills the requirements. The final validation of the OT modules with a ^{90}Sr radioactive source showed homogeneous responses of the modules over their active surface within $\pm 10\%$.
In 2005, beam tests of the OT modules were performed at the DESY laboratory. Four OT modules, equipped with front-end electronics, were irradiated with an electron beam of 6 GeV. The analysis of the beam test data (Chapter 4), showed a high detector efficiency ($\sim 98\%$), a coordinate resolution better than 200 μm, acceptable noise level ≤ 10 kHz/wire and modest cross talk ($< 5\%$).

To perform the studies described in the second part of this dissertation simulated data, produced as part of LHC*b* 2004 data challenge, were used.
The first part of these studies (Chapter 5) was devoted to the modeling of the behavior of the resolution of the B-mesons proper time. This resolution is an important ingredient in the measurement of the time-dependent (CP) asymmetries. The study was performed with B^+ and B^0 mesons, using the decay modes $B^+ \to J/\psi(\mu^+\mu^-)K^+$ and $B^0 \to J/\psi(\mu^+\mu^-)K^*(K^+\pi^-)$ and their conjugates. The resolution model is based on the proper-time residuals and the corresponding per-event errors. The parameters of the model were extracted in two ways: by using the known residuals from the simulated data and by using the proper time only (i.e. data that will be experimentally accessible). In addition to the precise determination of the resolution-model parameters, the method can be used to tune the LHC*b* Monte-Carlo (MC) algorithms.
The measurement of the B-meson lifetimes is a crucial element for the test of the theory. In particular, the Heavy Quark Expansion model (HQE) predicts a difference in the B^+ and B^0 lifetimes. According to the HQE $\tau_{B^+}/\tau_{B^0} = 1.06 \pm 0.02$ [30]. The final chapter of the dissertation (Chapter 6) focused on the extraction of the lifetime ratio τ_{B^+}/τ_{B^0} in the presence of backgrounds. The same B^+ and B^0 decay modes were used and the developed resolution model was applied. The ratio $\tau_{B^+}/\tau_{B^0} = 1.0826 \pm 0.0106$ has been determined, in good agreement with the input MC simulation value of 1.0879. It has also been found that in 1 year of data-taking at nominal luminosity and in the absence of other systematic errors, the LHC*b* experiment will measure the lifetimes of B^+ and B^0 mesons with a resolution of 1.71 ± 0.03 fs and 1.92 ± 0.01 fs, respectively, resulting in a sensitivity to τ_{B^+}/τ_{B^0} of 0.0017.